DESIGN AND FABRICATION OF A FOUR-MAN CAPACITY URINE WICK EVAPORATOR SYSTEM

FINAL REPORT

BY

DAVID F. PUTNAM

NOVEMBER 1978

PREPARED UNDER CONTRACT NO. NAS2-9677

BY

UMPQUA RESEARCH COMPANY

MYRTLE CREEK, OREGON

FOR

AMES RESEARCH CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

UMPQUA RESEARCH	DESIGN AND FABRICATION OF A FOUR-MAN CAPACITY URINE WICK EVAPORATOR SYSTEM FINAL REPORT NOVEMBER 1978 NASA CR 152276

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UMPQUA RESEARCH COMPANY

P.O. BOX 791, MYRTLE CREEK, OREGON 97457

1.0 INTRODUCTION AND SUMMARY

In this contract, Umpqua Research Company (URC) was responsible for the design and fabrication of a 4-man capacity urine wick evaporator system. This system was shipped to GARD, Inc., Niles, Illinois where it was integrated with a dual catalyst ammonia removal system built by GARD. The integrated system was then tested by GARD to determine the performance characteristics and limitations of the dual catalyst concept. The primary objective of the dual catalyst concept is to remove ammonia and other noxious substances in the gas phase and thereby eliminate the need for and current practice of chemically or electrochemically pretreating urine prior to distillation.

2.0 CONTRACTOR TASKS

2.1 Task 1 - 4-Man Capacity Urine Wick-Evaporator System

The baseline flow diagram of the integrated system is presented in Figure 1. This diagram shows: 1) all the major components of the integrated system; 2) the design temperatures for the air loop and 3) the basic division of responsibility between GARD and URC.

The wick-evaporator system constructed by URC consists of the following:

a. An air evaporation unit.

b. Four sets of replaceable wick assemblies.

c. An air blower.

d. A urine feed pump.

e. A urine holding tank.

f. Controls and instrumentation.

An artists conception of the packaged wick-evaporator system is presented in Figure 2. An assembly sketch depicting how the replaceable wick cartridge fits into its housing is shown in Figure 3.

The 4-man waste input model for this program was established as follows:

	urine lb/day	flush water lb/day	Total lb/day
Water	13.26	3.4	16.66
Solids	.54	0	.54
TOTAL	13.8	3.4	17.2

The duty cycle was selected as 20 hr/day. Therefore the average design waste input flow rate is:

$$W = 17.2 \text{ lb/day} \div 20 \text{ hr/day} = 0.86 \text{ lb/hr}$$

The required air flow to evaporate 0.86 lb/hr of water from the wick cartridge for the projected low flow and high flow conditions is indicated below:

wick inlet air temp °F	wick inlet dew point °F	AIR FLOW cfm	EVAPORATION RATE lb/hr
220	60	8	0.86
200	100	12	0.86

The components of the urine wick-evaporator system are discussed individually in the following paragraphs.

2.1.1 Air Evaporator Housing. This stainless steel housing, into which the wick evaporator cartridge is placed, can be seen in Figures 2 and 3. Figure 4 illustrates how to insert the wick cartridge and connect the urine feed line to the bulkhead fitting. When this operation is completed, the top plate must then be bolted in place.

2.1.2 Wick Evaporator Cartridges. The design was based upon previously tried and proven concepts using viscose rayon felt for the wicks, polyurethane foam for wick spacers and a series of manifolded feed tubes to supply urine at approximately 1-inch intervals along the transverse length of each wick segment. Sketches of the wick cartridge assembly, together with dimensions of the various components, are shown in Figures 5, 6, and 7.

2.1.3 Air Heater. A standard off-the-shelf 900 watt electrical air heater was selected and is shown in an assembly sketch in Figure 8.

2.1.4 Air Blower. A ROTRON SL2PL blower was selected. This 115 Vac-1 phase-50/60 Hz blower produces a 28" H_2O head at 12 cfm and uses 390 watts of power.

2.1.5 Urine Feed Pump. A Blue-White VS-1860 variable speed chemical metering pump was selected. This positive displacement diaphragm pump delivers a maximum flow of 315 cc/min and has a maximum outlet pressure of 60 psi. It comes with a vinyl suction tube, foot valve and polyethylene discharge tube. This pump was sized to provide "pulse" feeding to the wick, that is, high flow for short increments of time. This mode of operation is required to provide even urine distribution to the wicks without flooding. Sufficient time is provided between pulses to allow the pulsed volume of urine to be removed from its immediate discharge area, by the capillary action of the wick, before the following pulse occurs.

2.1.6 Urine Holding Tank. The urine holding tank is constructed of polyethylene plastic. It is approximately 42.8 cm x 35.5 cm x 24.7 cm high (16 7/8" x 14" x 9 3/4") with a hole in the top for filling and insertion of the pump suction tube with its foot valve. The suction tube/foot valve can be easily removed and dropped into a graduated cylinder or other tank if desired.

2.1.7 Controls and Instrumentation. A sketch of the control panel is shown in Figure 9. The system is started by activating: 1) the blower power switch; 2) the heater power switch and 3) the pump power switch. From this point on, everything works automatically. The heater controller was set to control the wick cartridge air inlet temperature to 200° F. The urine feed pump controller was set to feed urine when the wick cartridge air outlet temperature exceeded 130° F. The urine feed pump was timed to pulse feed urine as long as the controls called for feed. The "pump-on" and "pump off" intervals were initially set at 10 and 60 sec respectively. These intervals were individually adjustable.

The overall wiring diagram is shown in Figure 10. Wiring for the time delay relays to control the pulse feed cycle of the urine feed pump is also shown in Figure 10.

The operating procedure is summarized in Table 1.

2.1.8 Frame. A sketch of the aluminum mounting frame for the air evap components is shown in Figure 11.

TABLE 1. OPERATING PROCEDURE

1. Remove cover plate from unit.
2. Install wick packet per diagram shown. (Figure 4)
3. Check wick connector to verify unit is plugged into bulkhead fitting.
4. Replace cover (arrow toward outlet) and tighten screws.
5. Fill holding tank to desired level.
6. Turn on blower, heater and pump in that order.
7. Unit will control to 200° F on inlet, 130° F on outlet. (If temperature changes are required, they can be changed by removing blue covers on control units and adjusting with control knobs inside).

See CONTROL PANEL Diagram (Figure 9)

2.2 Task 2 - Preliminary Testing.

Preliminary and final functional tests were conducted at URC in accordance with the test plan presented in Appendix A. These tests demonstrated that all components functioned properly and that the wick evaporator system did meet its design objectives.

2.3 Task 3 - Integration and Test with Dual Catalyst Ammonia Removal System.

Technical consultation was provided to GARD during the integration and testing phase. In addition, several samples of the product water were analyzed for heavy metals, organics and other water quality tests recommended by EPA and the American Water Works Association (AWWA). These results are presented in Appendix B.

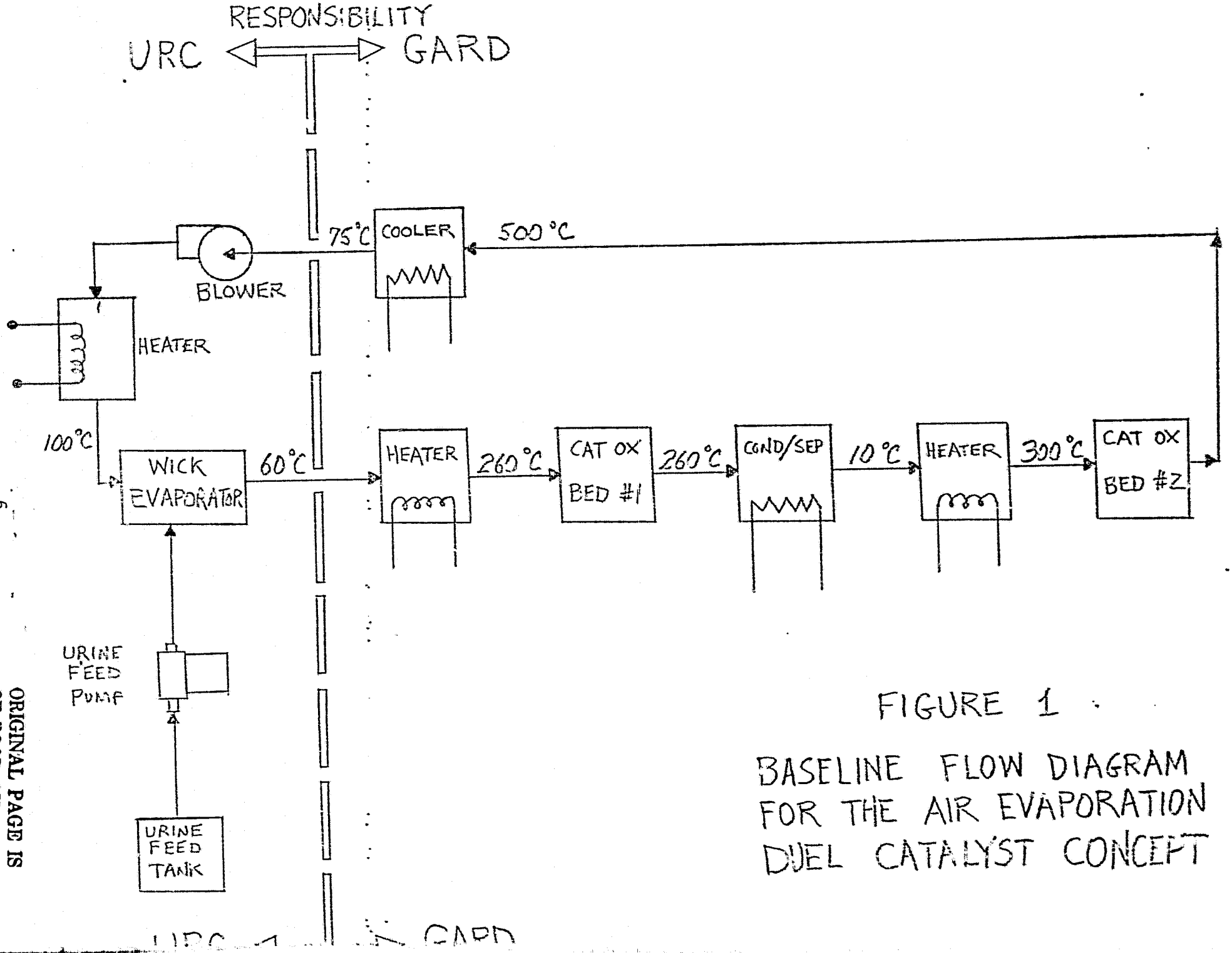
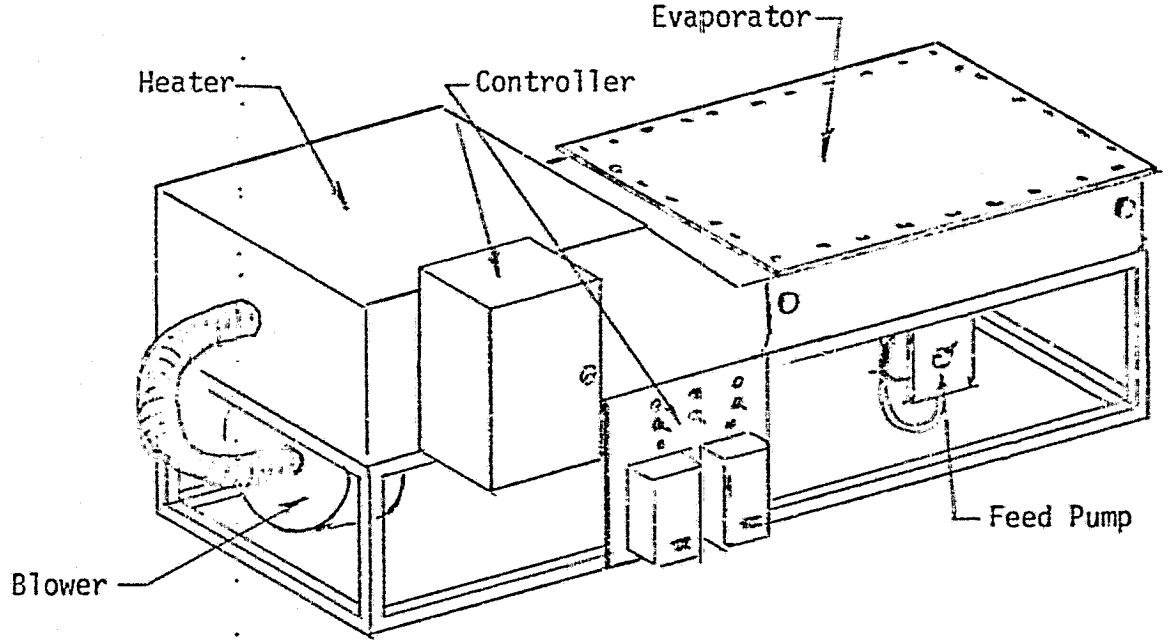


FIGURE 1

BASELINE FLOW DIAGRAM FOR THE AIR EVAPORATION DUEL CATALYST CONCEPT

FIGURE 2. WICK EVAPORATOR SYSTEM ASSEMBLY



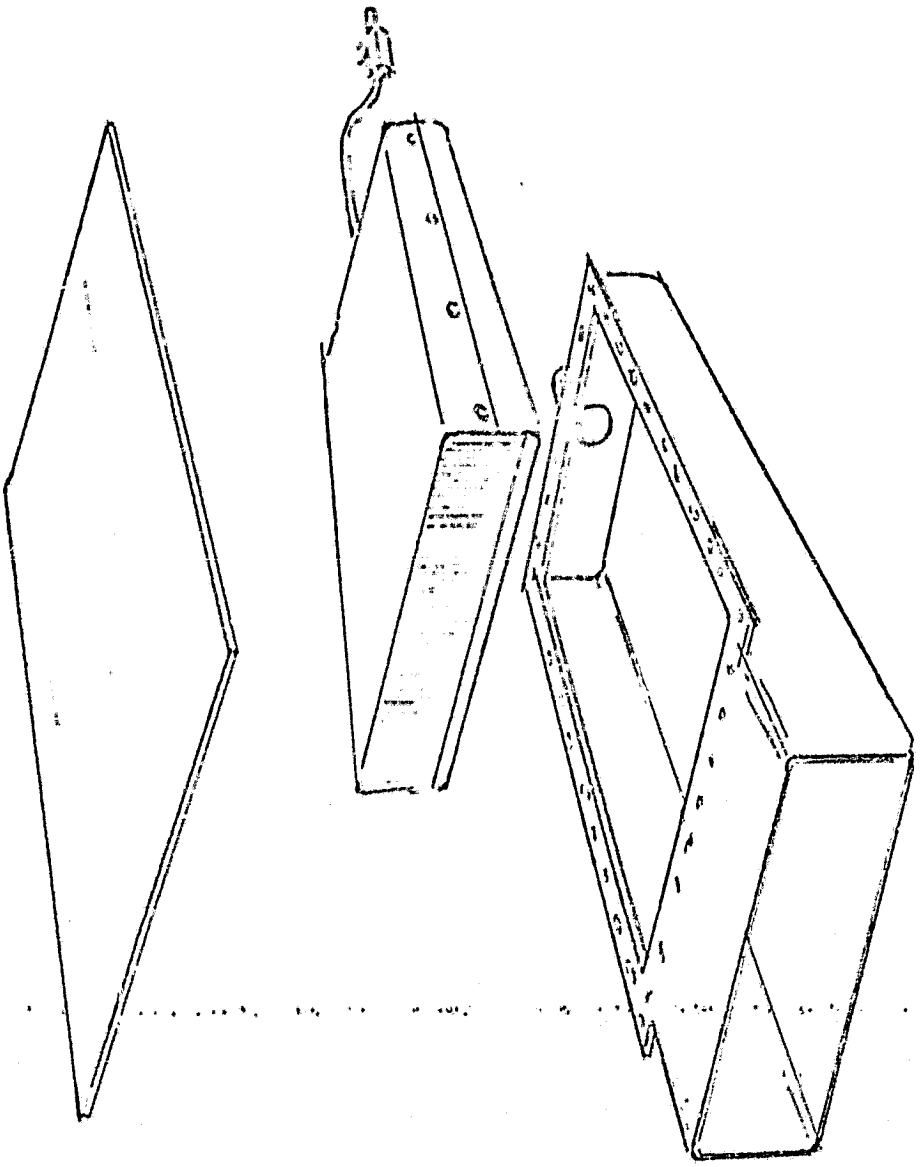


FIGURE 3. WICK CARTRIDGE AND HOUSING

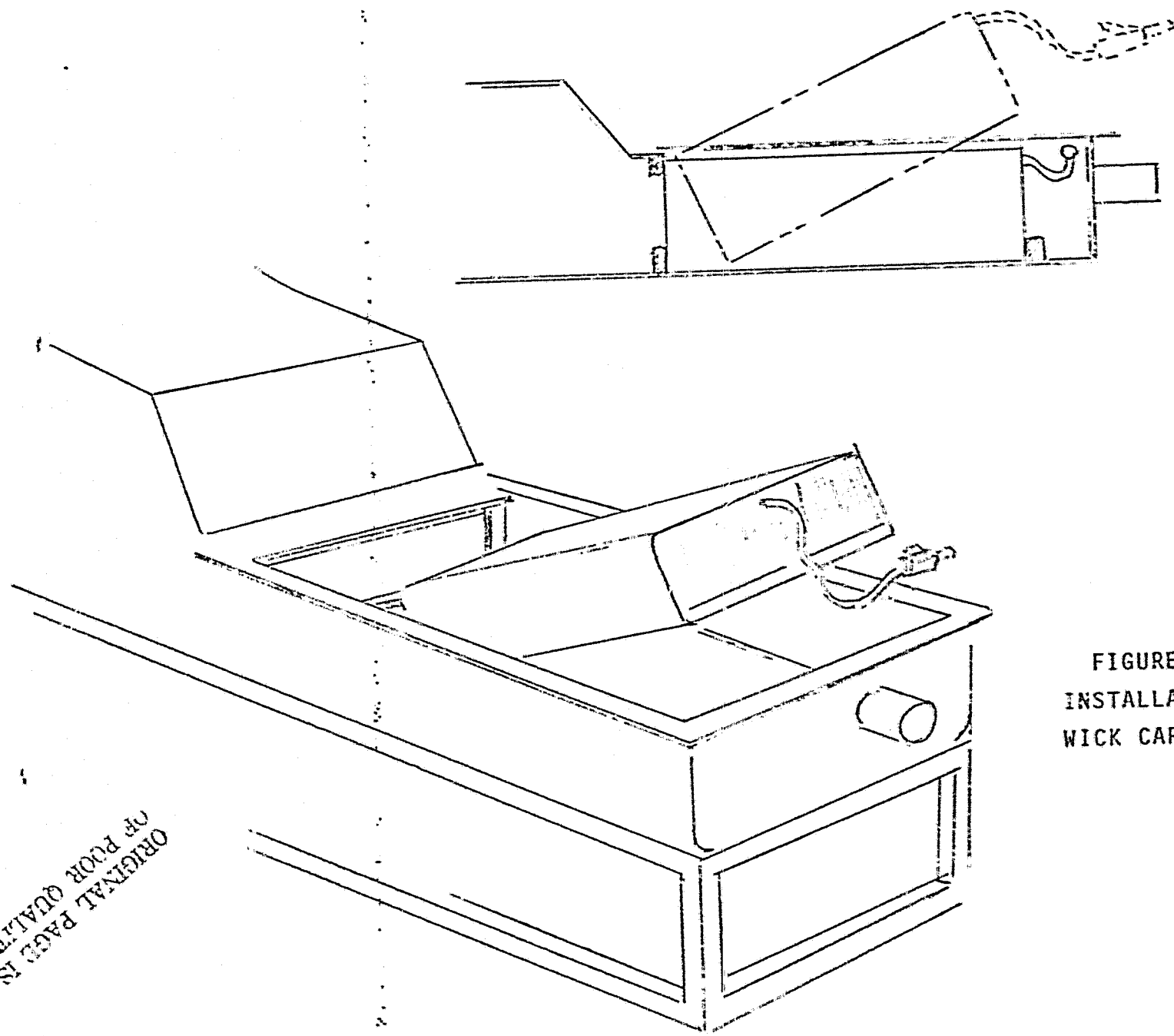
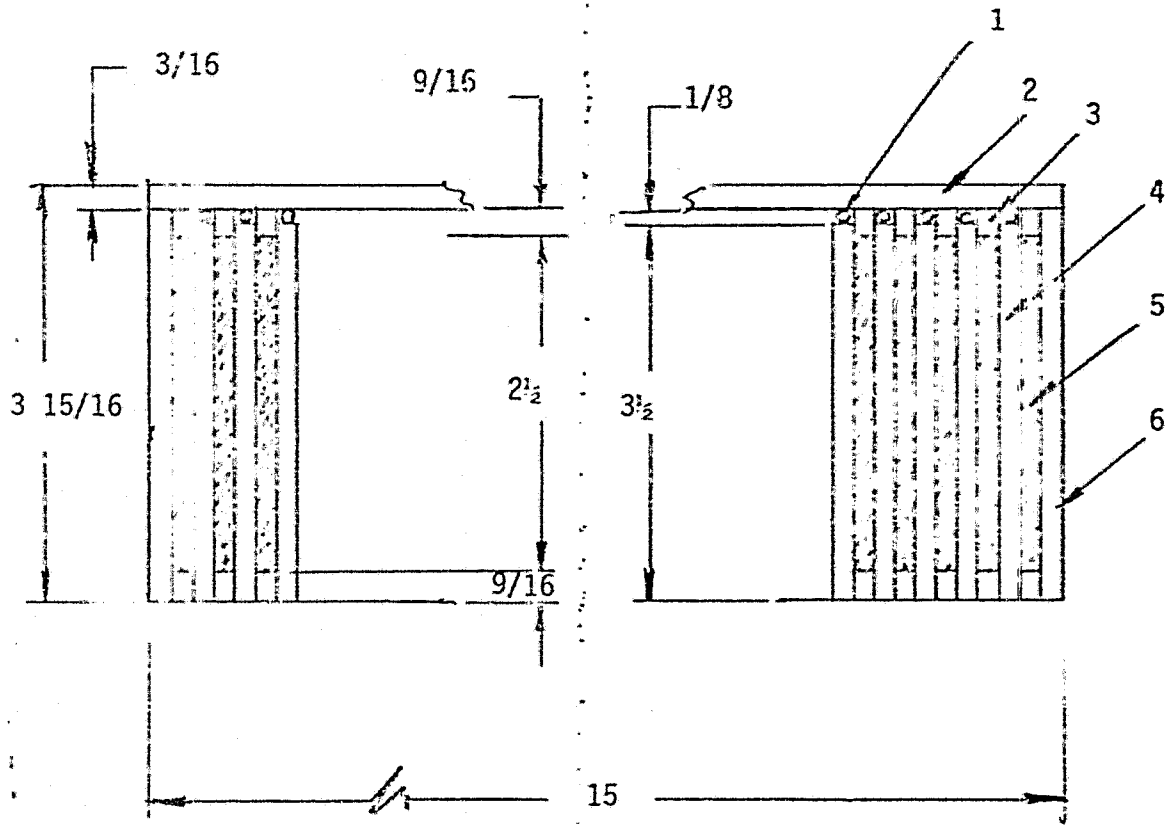
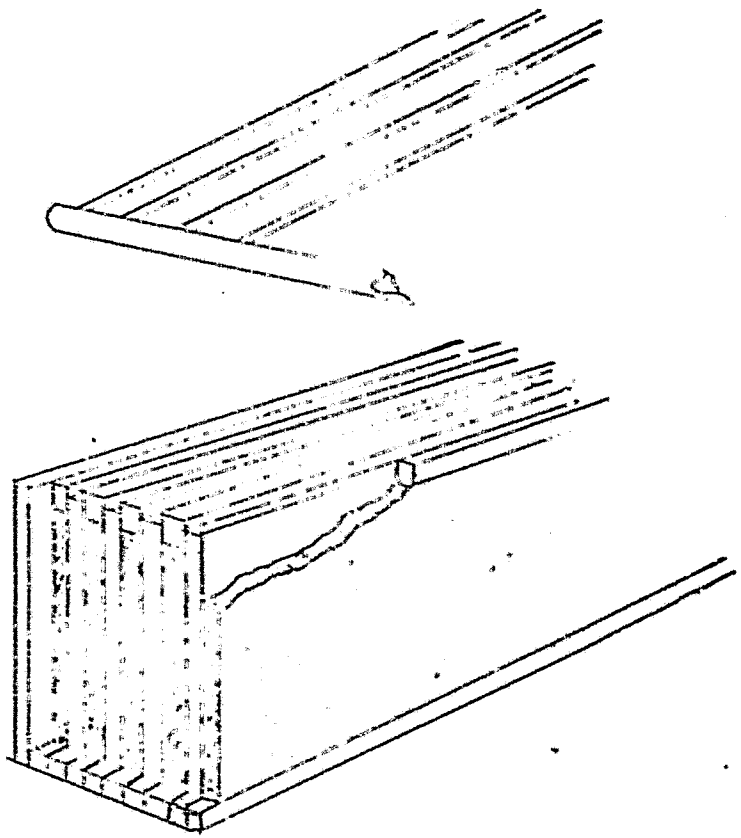


FIGURE 4.
INSTALLATION OF
WICK CARTRIDGE





ITEM	DESCRIPTION	QUANTITY
1	- FEED TUBE	30
2	- FELT TOP PIECE	1
3	- FELT SPACER	62
4	- FELT WICK	30
5	- FOAM SPACER	31
6	- FELT END PIECE	2

FIGURE 5. WICK CARTRIDGE ASSEMBLY

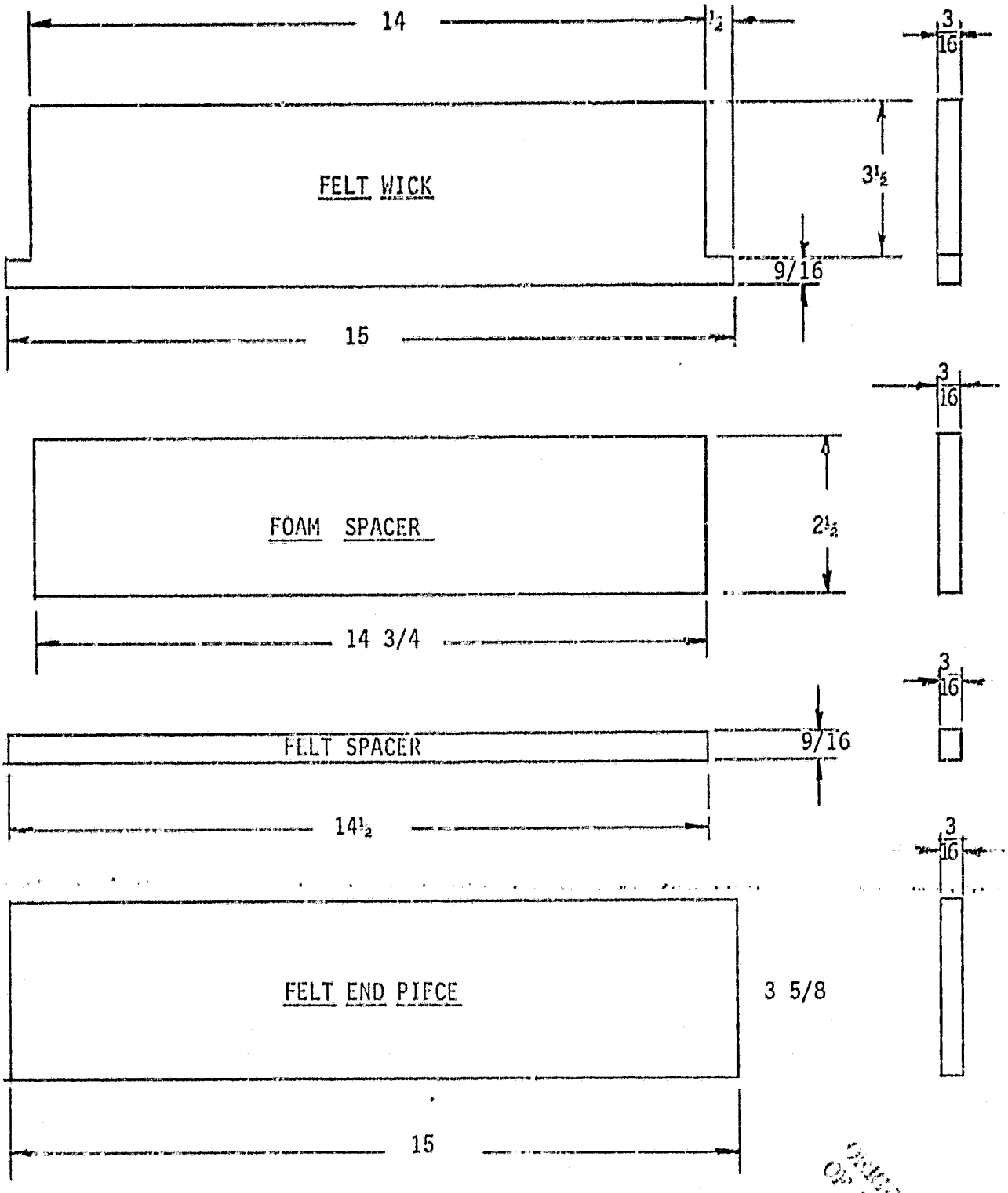
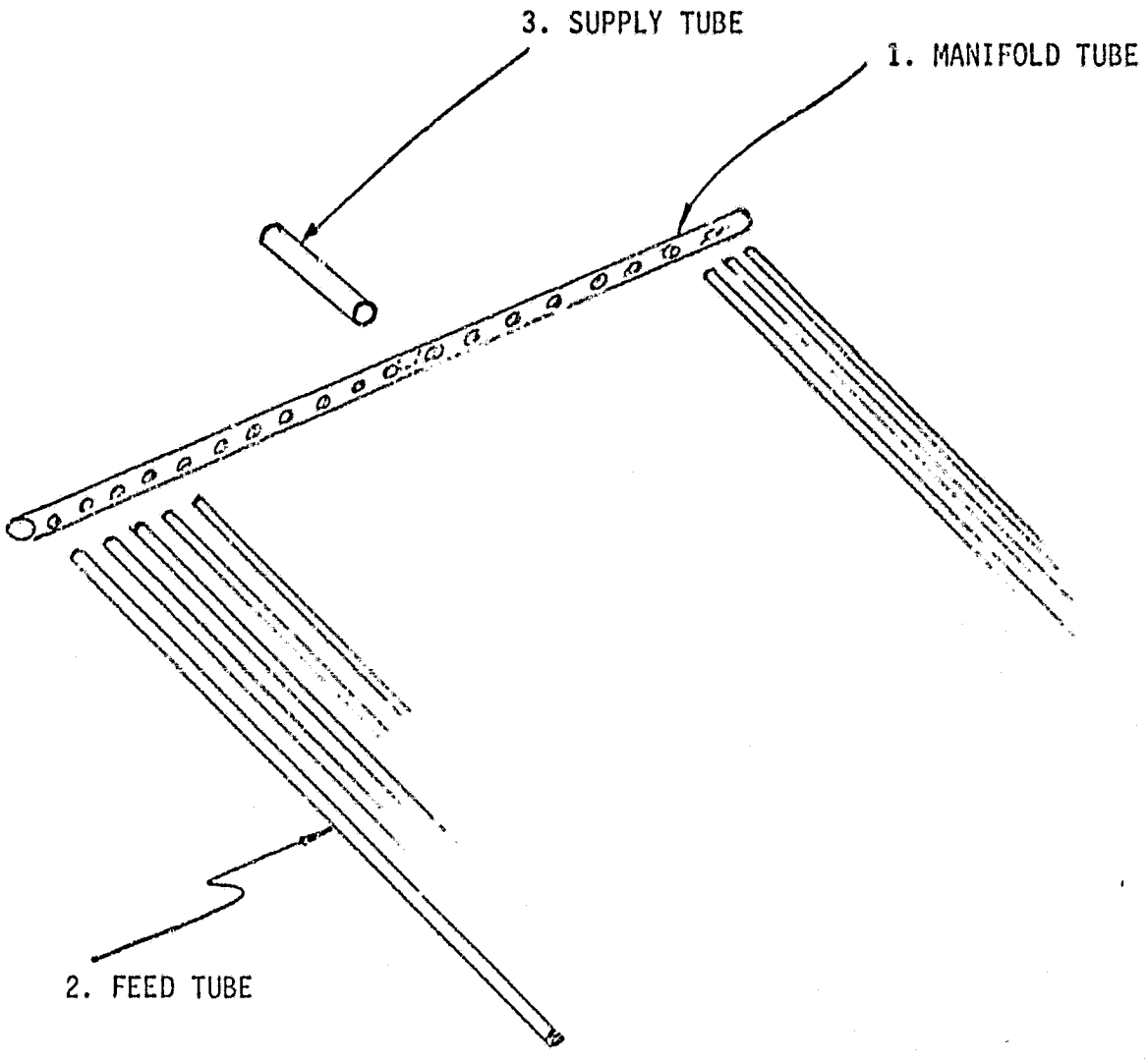


FIGURE 6. WICK CARTRIDGE COMPONENTS

FIGURE 7. FEED TUBE ASSEMBLY



ITEM	DESCRIPTION
1.	MANIFOLD TUBE - 5/16" O.D. 14 3/4" LONG (1 REQ'D) DRILL 30 EA. .122" DIA HOLES @ .47" INCREMENTS TO ACCEPT FEED TUBES. BEGIN AT .56" IN ONE END. TO BE DRILLED IN LINE THRU ONE WALL ONLY. OPPOSITE SIDE OF 30 EA. .122 DIA HOLES, 7 3/8" OR CENTER DRILL .250 DIA HOLE THRU ONE WALL
2.	FEED TUBE - 1/8" O.D. 12¼" LONG (30 REQ'D) DRILL #80 DIA DRILL EQUALLY SPACED @ 2 3/8" INCREMENTS. TO BE DRILLED IN LINE THRU ONE WALL ONLY.
3.	SUPPLY TUBE - 1/4" O.D. 1 3/4" LONG (1 REQ'D) TO BE INSTALLED TO 5/16" DIA MANIFOLD TUBE.

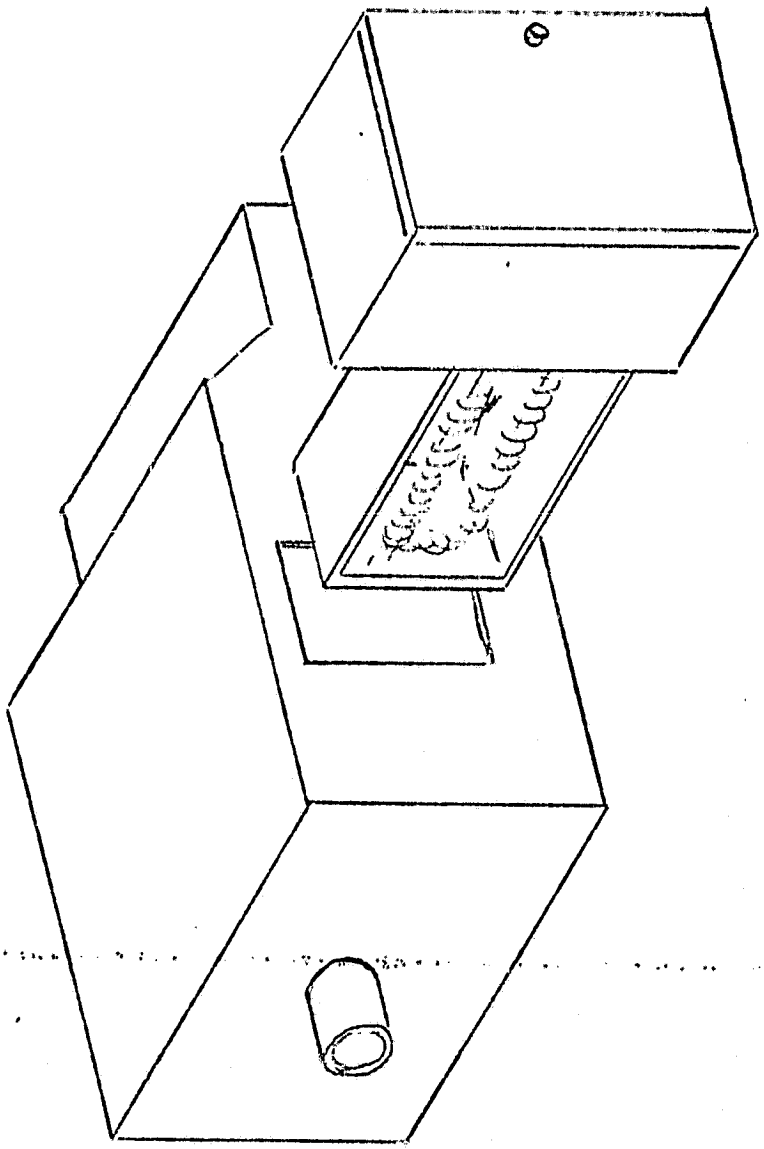
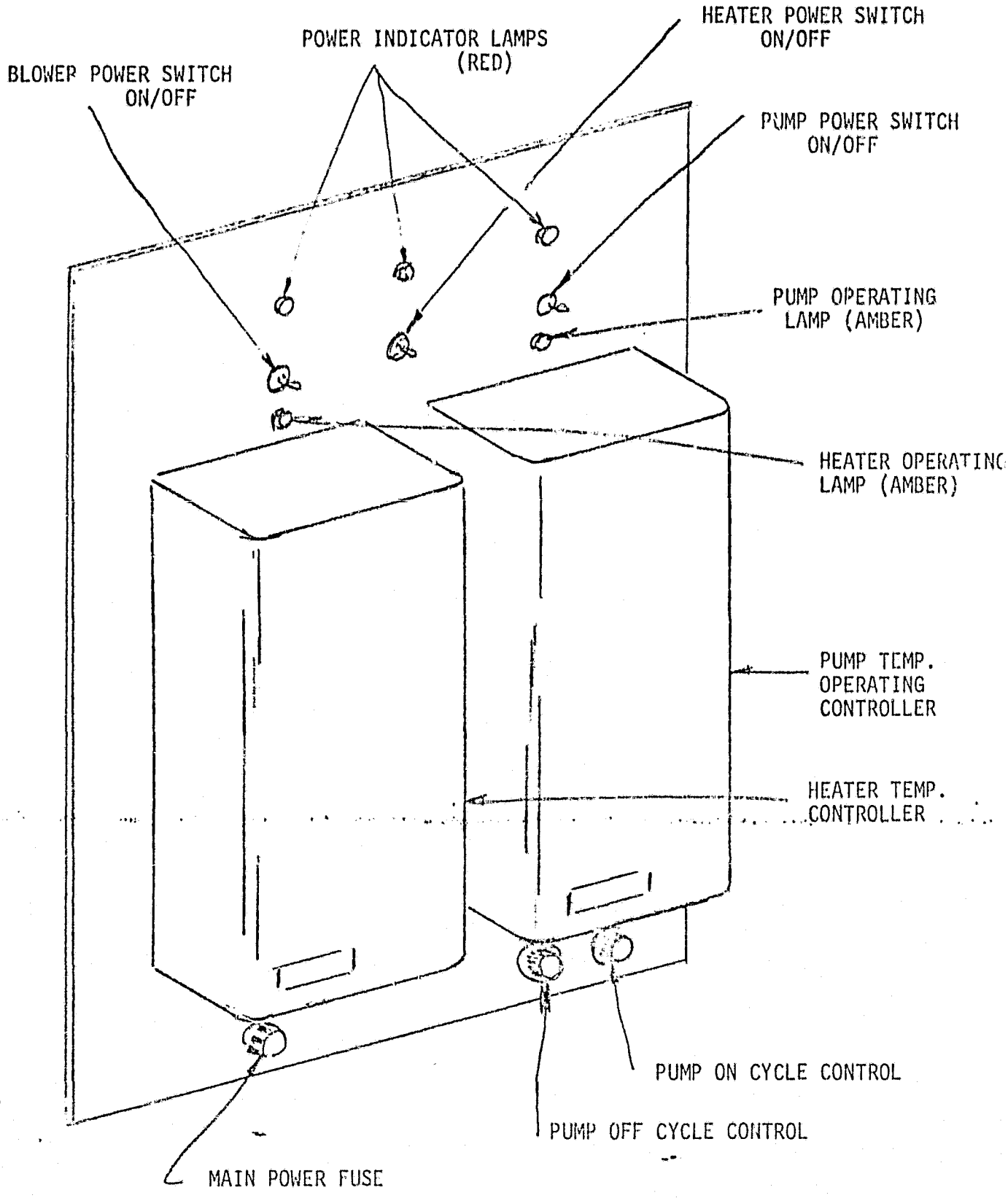


FIGURE 8. AIR HEATER ASSEMBLY

FIGURE 9. CONTROL PANEL



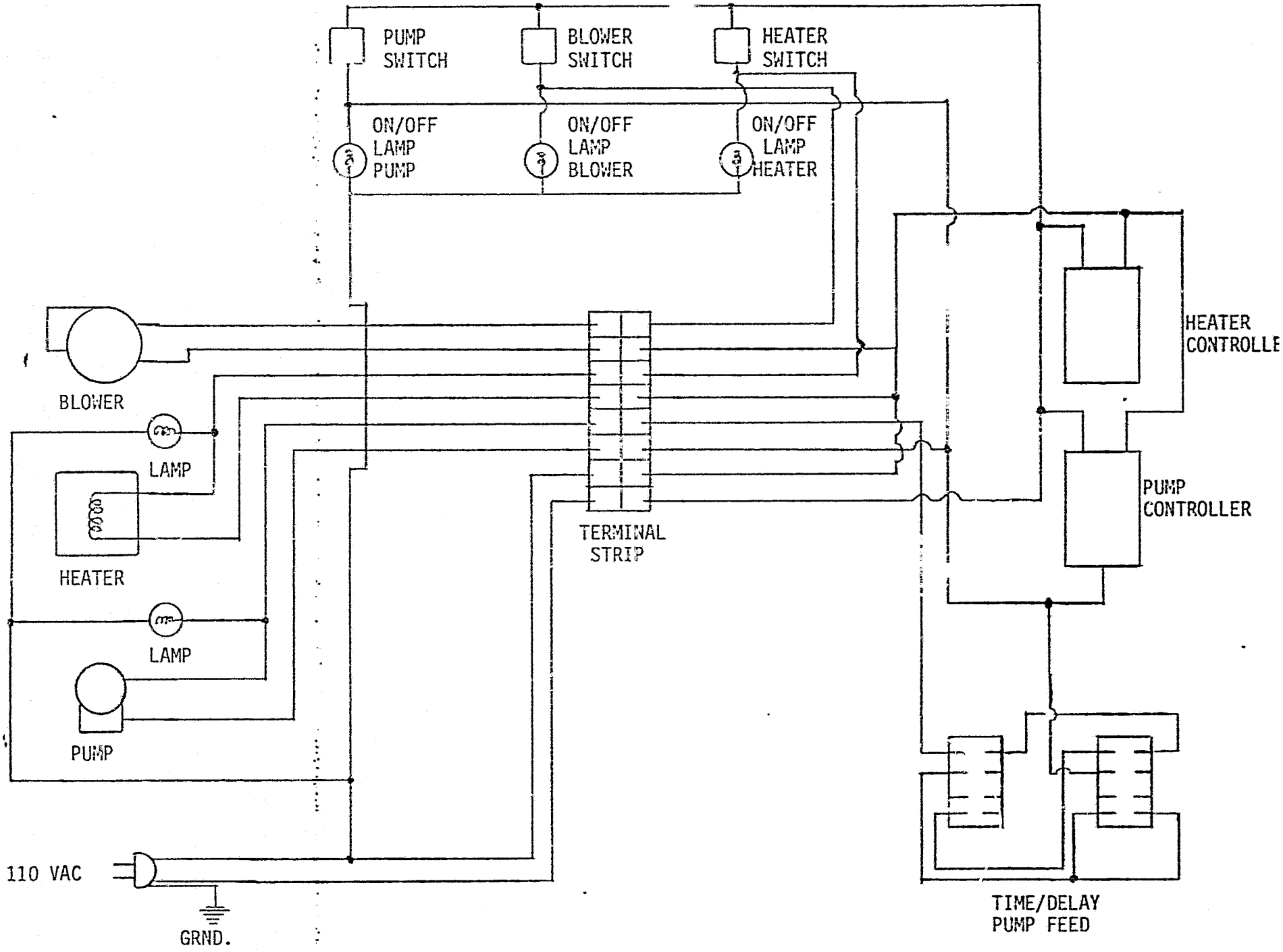
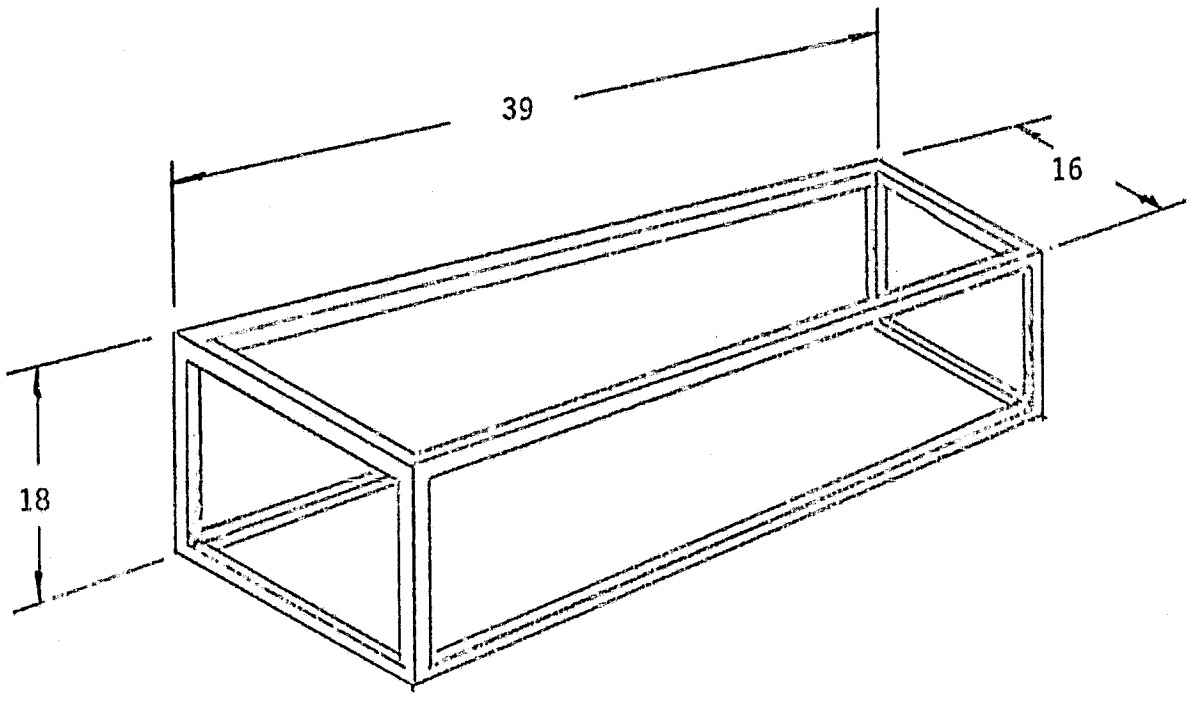


FIGURE 10. OVERALL WIRING DIAGRAM

FIGURE 11. MOUNTING FRAME



APPENDIX A

FUNCTIONAL TEST PLAN

APPENDIX A

UMPQUA RESEARCH COMPANY

P. O. Box 791
Myrtle Creek, Oregon 97457

626 N.E. Division Street
Telephone (503) 863-5201

FUNCTIONAL TEST PLAN

FOR

URINE WICK EVAPORATOR SYSTEM

NAS2-9677

APRIL 6, 1978

FOR

P.D. QUATTRONE
AMES RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Subject. Functional test of the Urine Wick-Evaporator System.

Test Objectives. Verification that individual components, controls and instrumentation are functioning properly and that the system performance meets the design objectives.

System Description. A schematic diagram of the system is presented in Figure 1. A blower delivers air to an electrical heater that raises the air temperature to any desired value between ambient and 220°F. The heated air then passes through the wick evaporator where it picks up moisture from the wet wicks by adiabatic evaporation. In this evaporation process the temperature of the air stream is lowered. The temperature drop is related to the amount of water evaporated. Urine is fed to the wick evaporator from the raw urine tank by a positive displacement pump. The pump is controlled by a temperature signal from the exit air stream. The pump operates in a "pulse feed" mode. The timing of the pulses is controlled by two adjustable time delay relays.

Design Objectives. The urine wick-evaporator system has the following design objectives:

parameter	condition #1	condition #2
evaporation rate, lb/hr	0.86	0.86
wick inlet dew point, °F	60	100
wick inlet air temp, °F	220	200
air flow, cfm	8	12
blower head, in H_2O	28	27

Test Description. The functional test will be run in the open cycle mode. That is, ambient air will be used. Flow will be adjusted to 12 cfm and the heater exit temperature controller will be set at 200°F. The raw urine tank will be filled with a measured amount of distilled water. The urine feed pump controller will be set to control the wick evaporator exit temperature at 150°F. The pulse feed controller will be set initially at 15 seconds on and 45 seconds off. The functional test will be run continuously for a period of 6 hours. Temperatures, dew points, blower head and component pressure drops will be recorded at 1/2 hour intervals. The wick evaporator exit temperature and power to the urine feed pump will be monitored on a strip chart recorder to provide a visual history of the pulse feed mode. A record of the amount of water fed to the wick evaporator will also be kept.

This test will demonstrate that all components are functioning properly and that the wick evaporator system will meet its design objectives.

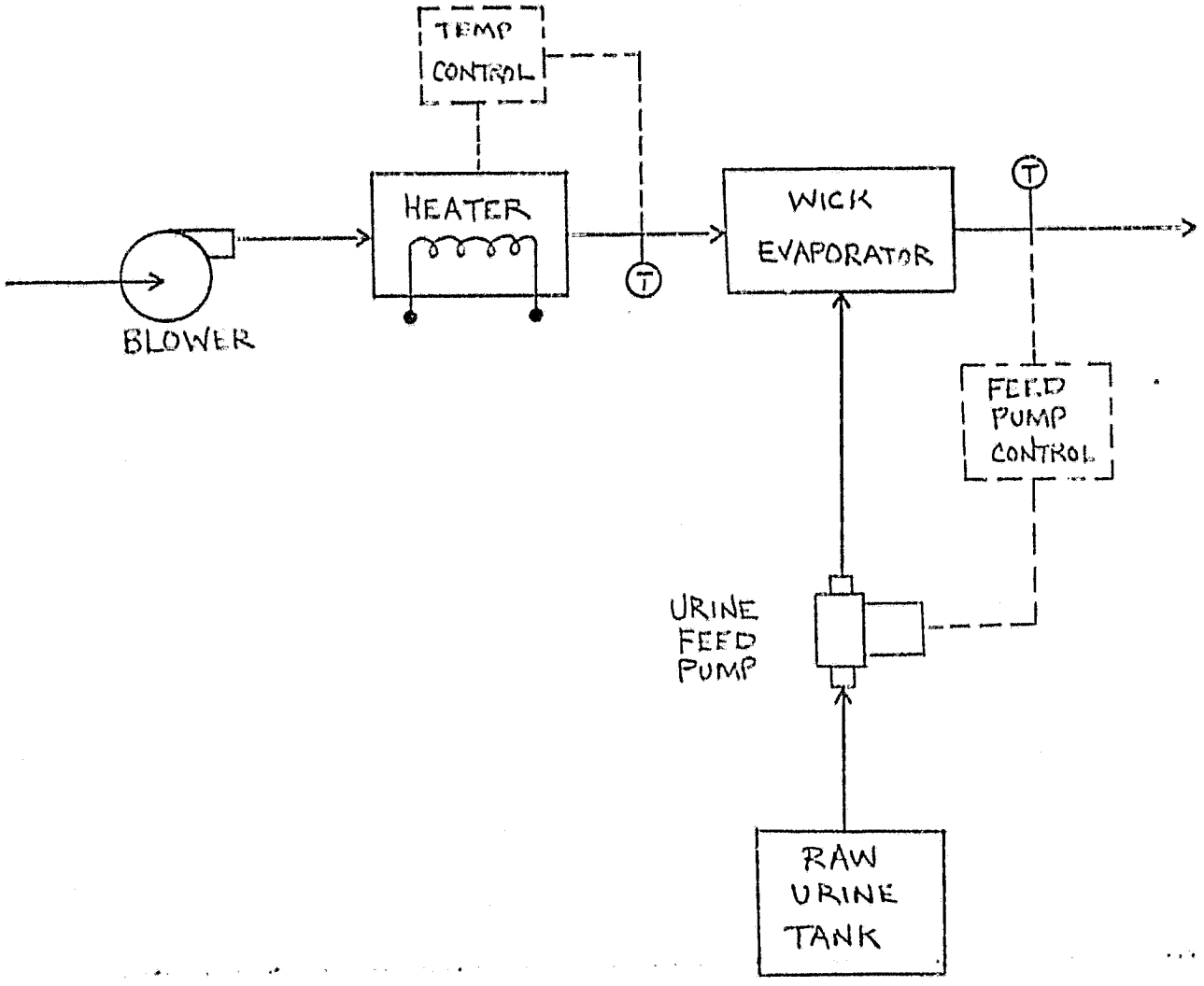


FIGURE A1. Wick Evaporator System Schematic

APPENDIX B

PHYSICAL AND CHEMICAL TEST RESULTS ON PRODUCT WATER FROM THE INTEGRATED SYSTEM

Set #1

UMPQUA RESEARCH COMPANY

P. O. Box 791
Myrtle Creek, Oregon 97457

626 N.E. Division Street
Telephone (503) 863-5201

EPA Interim Primary Drinking Water Standards

NAME GARD, Inc, Attn: Frank Budininkas — DATE & TIME COLLECTED Wk of 10-6-78
ADDRESS 7449 N. Natchez Ave., Niles, Ill 60648 — DATE RECEIVED 10-20-78
WATER SOURCE NASA - Water Recovery Set #1 — DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81020-1

TEST	TEST METHOD[1]	UNITS	LIMITS	TEST RESULTS	DATE OF ANALYSIS	ANALYST
ARSENIC	SM 404 C	MG/L	0.05	N.D.@ 0.01	10-25-78	MJS
BARIUM	SM 303 A	MG/L	1.	N.D.@ 0.1	11-2-78	MJS
CADMIUM	SM 305 A	MG/L	0.01	0.0019	11-7-78	DRG
CHROMIUM	SM 307 A	MG/L	0.05	N.D.@ 0.02	11-1-78	MJS
LEAD	SM 311 A	MG/L	0.05	0.106	11-7-78	GVC
MERCURY	SM 315 A	MG/L	0.002	0.24	11-9-78	DRG
NITRATE-NITROGEN	ASTM D992-71	MG/L	10.	1.0	10-25-78	MJS
SELENIUM	SM 318 C	MG/L	0.01	N.D.@ 0.002	11-1-78	MJS
SILVER	SM 319 A	MG/L	0.05	N.D.@ 0.01	11-1-78	MJS
FLUORIDE	SM 414A & C	MG/L	1.4 to 2.4	1.0	11-1-78	MJS
ENDRIN	SM 509 A	MG/L	0.0002	NOT TESTED		
LINDANE	SM 509 A	MG/L	0.004	" "		
METHOXYCHLOR	SM 509 A	MG/L	0.1	" "		
TOXAPHENE	SM 509 A	MG/L	0.005	" "		
2,4-D	SM 509 B	MG/L	0.1	" "		
2,4,5-TP SILVEX	SM 509 B	MG/L	0.01	" "		
pH	SM 424	pH Units		3.8	10-20-78	DRG
SPECIFIC CONDUCTANCE	SM 205	µMHO/CM		54	10-20-78	DRG

[1] EPA = Methods for the Chemical Analysis of Water & Wastes, 1974
SM = Standard Methods for the Examination of Water & Wastewater, 14th Edition
ASTM = ASTM Annual Standards, Part 31
N.D. = None Detectable

APPROVED BY: David T. Putnam

Set #1

UMPQUA RESEARCH COMPANY

Water and Air Technology

P. O. Box 791 ◆ Telephone (503) 863-5201

626 N.E. Division Street Myrtle Creek, Oregon 97457

Gerald V. Colombo

David F. Putnam

TEST RESULTS

NAME GARD, Inc. ATTN Frank Budininkas DATE 10-20-78

ADDRESS 7449 N. Natchez Ave., Niles, Ill. 60648 DATE REPORTED 12-1-78

TEST	SOURCE	Set #1	ANALYSIS	ANALYST	
	DATE TESTED		DATE		
	SAMPLE # / UNITS	81020-1			
pH	pH Units	3.8	10-20-78	DRG	
SPECIFIC CONDUCTIVITY	µ mho/cm	54	10-20-78	DRG	
AMMONIA	mg/liter	0.44	11-20-78	DRG	
CYANIDE	mg/liter	no sample			
T.O.C.	mg/liter	2.5	11-27-78	DRG	
G.C. SCAN	hydrocarbon	negative	12-1-78	GVC	

APPROVED BY- David F. Putnam

Set #1

UMPQUA RESEARCH COMPANY

P. O. Box 791 ◆ 626 N.E. Division Street
Myrtle Creek, Oregon 97457 Telephone (503) 863-5201

PHYSICAL AND CHEMICAL TESTS REQUIRED BY OREGON STATE HEALTH DIVISION ADMINISTRATIVE RULES CHAPTER 333, MARCH 1976

NAME GARD, Inc. DATE & TIME COLLECTED Wk of 10-6-78
ADDRESS 7449 N. Natchez Ave., Niles, Ill. 60648 DATE RECEIVED 10-20-78
WATER SOURCE NASA-Water recovery Set #1 DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81020-1

TEST	TEST METHOD[1]	UNITS	OSHD LIMITS	TEST RESULTS	ANALYSIS DATE	ANALYST
ACIDITY	SM 403	MG/L	N.L.	**		
CALCIUM	SM 306 A	MG/L	N.L.	0.73	11-2-78	MJS
CHLORIDES	SM 408 A	MG/L	250.	2.6	11-10-78	DRG
COLOR (APPARENT)	SM 204 A	COLOR	15.	5	11-10-78	DRG
COPPER	SM 308 A	MG/L	1.0	0.14	11-2-78	MJS
FLUORIDE	SM 414 C	MG/L	2.0	1.0	11-1-78	MJS
HARDNESS ($CaCO_3$)	SM 309 B	MG/L	N.L.	**		
IRON	SM 310 B	MG/L	0.3	0.38	11-1-78	MJS
MAGNESIUM	SM 313 B	MG/L	N.L.	0.09	11-2-78	MJS
MANGANESE	SM 314 A	MG/L	0.05	0.01	11-2-78	MJS
NITROGEN, NITRATE	ASTM D992-71	MG/L	10.	1.0	10-25-78	MJS
NITROGEN, NITRITE	EPA p.215	MG/L	N.L.	N.D. @ 0.01	10-25-78	DG
ODOR	SM 206	T.O.N.	3.	1	10-20-78	DG
pH	SM 424	pH	N.L.	3.8	10-20-78	DG
*POTASSIUM	SM 317 A	MG/L	N.L.	0.05	11-2-78	MJS
SAND	SM 208 D,E	MG/L	2.	N.D. @ 1	11-1-78	MJS
SILICA	SM 426 B	MG/L	N.L.	**		
SODIUM	SM 320 A	MG/L	N.L.	0.23	11-2-78	MJS
SOLIDS, TOTAL	SM 208 C	MG/L	1000.	**		
SOLIDS, VOLATILE	SM 208 E	MG/L	N.L.	**		
*SPECIFIC CONDUCTANCE	SM 205	µMHO/CM	N.L.	59	10-20-78	DG
SULFATES	SM 427 B	MG/L	250.	**		
TURBIDITY	SM 214 A	F	Filtered 1.0 Unfiltered 5.0	0.8	11-10-78	DG
ZINC	SM 303 A	MG/L	5.0	0.22	11-1-78	MJS

*Required by Laboratory for completion of Ion Balance and Quality Control of the Results.
"N.L." means No Limit
N.D. means None Detectable
**Insufficient sample

APPROVED BY: David A. Putnam

UMPQUA RESEARCH COMPANY

P. O. Box 791
Myrtle Creek, Oregon 97457

626 N.E. Division Street
Telephone (503) 863-5732

GARD, Inc.
Niles, Ill.
Set #1

ION BALANCE

Sample No.	81020-1			
CATIONS, meq/l:				
Ca^{++}	0.036			
Mg^{++}	0.007			
K^{+}	0.001			
Na^{+}	0.010			
H^{+}	0.158			
ΣCATIONS	0.212			
ANIONS, meq/l:				
HCO_3^{-}	0			
$CO_3^{=}$	0			
Cl^{-}	0.073			
NO_3^{-}	0.071			
$SO_4^{=}$	-			
Fl^{-}	0.053			
ΣANIONS	0.197			
|ΣANIONS - ΣCATIONS|	0.015			
0.1065 + 0.0155ΣANIONS	0.113			
Acceptable* Ion Balance	YES			

Remarks:

*For acceptable comparability, $|\Sigma ANIONS - \Sigma CATIONS| \leq 0.1065 + 0.0155\Sigma ANIONS$

Set #2

UMPQUA RESEARCH COMPANY

P. O. Box 791
Myrtle Creek, Oregon 97457

626 N.E. Division Street
Telephone (503) 863-5201

EPA Interim Primary Drinking Water Standards

NAME GARD, Inc. Attn: Frank Budininkas DATE & TIME COLLECTED _____
ADDRESS 7449 N. Natchez Ave.,Niles,Ill. 60648 DATE RECEIVED 10-20-78
WATER SOURCE Set #2 DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81020-2

TEST	TEST METHOD[1]	UNITS	LIMITS	TEST RESULTS	DATE OF ANALYSIS	ANALYST
ARSENIC	SM 404 C	MG/L	0.05	N.D.@ 0.01	10-25-78	MJS
BARIUM	SM 303 A	MG/L	1.	N.D@0.1	11-2-78	MJS
CADMIUM	SM 305 A	MG/L	0.01	0.0015	11-7-78	DRG
CHROMIUM	SM 307 A	MG/L	0.05	N.D.@ 0.02	11-1-78	MJS
LEAD	SM 311 A	MG/L	0.05	0.023	11-7-78	DRG
MERCURY	SM 315 A	MG/L	0.002	0.28	11-9-78	DRG
NITRATE-NITROGEN	ASTM D992-71	MG/L	10.	0.7	10-25-78	MJS
SELENIUM	SM 318 C	MG/L	0.01	N.D@0.002	11-1-78	MJS
SILVER	SM 319 A	MG/L	0.05	N.D@0.01	11-1-78	MJS
FLUORIDE	SM 414A & C	MG/L	1.4 to 2.4	1.9	11-12-78	DRG
ENDRIN	SM 509 A	MG/L	0.0002	NOT TESTED		
LINDANE	SM 509 A	MG/L	0.004	" "		
METHOXYCHLOR	SM 509 A	MG/L	0.1	" "		
TOXAPHENE	SM 509 A	MG/L	0.005	" "		
2,4-D	SM 509 B	MG/L	0.1	" "		
2,4,5-TP SILVEX	SM 509 B	MG/L	0.01	" "		
pH	SM 424	pH Units		3.6	10-20-78	DRG
SPECIFIC CONDUCTANCE	SM 205	µMHO/CM		92	10-20-78	DRG

[1] EPA = Methods for the Chemical Analysis of Water & Wastes, 1974
SM = Standard Methods for the Examination of Water & Wastewater, 14th Edition
ASTM = ASTM Annual Standards, Part 31
N.D. = None Detectable

APPROVED BY: David F. Putnam

Set #2

UMPQUA RESEARCH COMPANY

Water and Air Technology

P. O. Box 791 ◆ Telephone (503) 863-5201

626 N.E. Division Street Myrtle Creek, Oregon 97457

Gerald V. Colombo

David F. Putnam

TEST RESULTS

NAME GARD, Inc. ATTN Frank Budininkas DATE 10-20-78

ADDRESS 7449 N. Natchez Ave., Niles, Ill 60648 DATE REPORTED 12-1-78

TEST	SOURCE	Set #2	ANALYSIS	ANALYST	
	DATE TESTED		DATE		
	SAMPLE # / UNITS	81020-2			
pH	pH Units	3.6	10-20-78	DRG	
SPECIFIC CONDUCTIVITY	μ mho/cm	92	10-20-78	DRG	
AMMONIA	mg/liter	0.40	11-20-78	DRG	
CYANIDE	mg/liter	N.D. 0.02	11-20-78	DRG	
GC SCAN	hydrocarbon	negative	12-1-78	GVC	
T.O.C.	mg/liter	1.2	11-27-78	DRG	

APPROVED BY Jarrett F. Putnam

Set #2

UMPQUA RESEARCH COMPANY

P. O. Box 791 ◆ 626 N.E. Division Street
Myrtle Creek, Oregon 97457 Telephone (503) 863-5201

PHYSICAL AND CHEMICAL TESTS REQUIRED BY OREGON STATE HEALTH DIVISION ADMINISTRATIVE RULES CHAPTER 333, MARCH 1976

NAME GARD, Inc. Attn: Frank Budininkas DATE & TIME COLLECTED _____
ADDRESS 7449 N. Natchez Ave.,Niles,Ill. 60648 DATE RECEIVED 10-20-78
WATER SOURCE Set #2 DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81020-2

TEST	TEST METHOD[1]	UNITS	OSHD LIMITS	TEST RESULTS	ANALYSIS DATE	ANALYST
ACIDITY	SM 403	MG/L	N.L.	14.1	11-14-78	DRG
CALCIUM	SM 306 A	MG/L	N.L.	0.69	11-2-78	MJS
CHLORIDES	SM 408 A	MG/L	250.	5.59	10-26-78	DRG
COLOR (APPARENT)	SM 204 A	COLOR	15.	5	11-10-78	DRG
COPPER	SM 308 A	MG/L	1.0	0.04	11-2-78	MJS
FLUORIDE	SM 414 C	MG/L	2.0	1.9	11-12-78	DRG
HARDNESS ($CaCO_3$)	SM 309 B	MG/L	N.L.	2.0	10-23-78	DRG
IRON	SM 310 B	MG/L	0.3	0.29	11-1-78	MJS
MAGNESIUM	SM 313 B	MG/L	N.L.	0.09	11-2-78	MJS
MANGANESE	SM 314 A	MG/L	0.05	0.01	11-2-78	MJS
NITROGEN,NITRATE	ASTM D992-71	MG/L	10.	0.7	10-25-78	MJS
NITROGEN, NITRITE	EPA p.215	MG/L	N.L.	N.D.@ 0.01	10-25-78	DRG
ODOR	SM 206	T.O.N.	3.	N.D.@ 1	10-20-78	DRG
pH	SM 424	pH	N.L.	3.6	10-20-78	DRG
*POTASSIUM	SM 317 A	MG/L	N.L.	0.07	11-2-78	MJS
SAND	SM 208 D,E	MG/L	2.	N.D.@ 0.1	11-15-78	DRG
SILICA	SM 426 B	MG/L	N.L.	0.64	11-3-78	DRG
SODIUM	SM 320 A	MG/L	N.L.	0.24	11-2-78	MJS
SOLIDS, TOTAL	SM 208 C	MG/L	1000.	1.8	11-15-78	DRG
SOLIDS, VOLATILE	SM 208 E	MG/L	N.L.	N.D.@ 0.1	11-16-78	DRG
*SPECIFIC CONDUCTANCE	SM 205	µMHO/CM	N.L.	92	10-20-78	DRG
SULFATES	SM 427 B	MG/L	250.	0.29	10-26-78	DRG
TURBIDITY	SM 214 A	F	Filtered 1.0 Unfiltered 5.0	N.D.@ 0.1	11-10-78	DRG
ZINC	SM 323 A	MG/L	5.0	0.08	11-1-78	MJS

*Required by Laboratory for completion of Ion Balance and Quality Control of the Results.
"N.L." means No Limit
N.D. means None Detectable

APPROVED BY: David T. Pittman

UMPQUA RESEARCH COMPANY

P. O. Box 791 ◆ 626 N.E. Division Street
Myrtle Creek, Oregon 97457 Telephone (503) 863-5732

GARD, Inc.
Niles, Ill.

ION BALANCE

Set #2

Sample No.	81020-2			
CATIONS, meq/l:				
Ca^{++}	0.034			
Mg^{++}	0.007			
K^{+}	0.002			
Na^{+}	0.010			
H^{+}	0.251			
ΣCATIONS	0.304			
ANIONS, meq/l:				
HCO_3^{-}	0			
$CO_3^{=}$	0			
Cl^{-}	0.158			
NO_3^{-}	0.050			
$SO_4^{=}$	0.006			
Fl^{-}	0.100			
ΣANIONS	0.314			
|ΣANIONS - ΣCATIONS|	0.100			
0.1065 + 0.0155ΣANIONS	0.116			
Acceptable* Ion Balance	YES			

Remarks:

ORIGINAL PAGE IS
OF POOR QUALITY

*For acceptable comparability, $|\Sigma ANIONS - \Sigma CATIONS| \leq 0.1065 + 0.0155\Sigma ANIONS$

Set.#3

UMPQUA RESEARCH COMPANY

P. O. Box 791
Myrtle Creek, Oregon 97457

626 N.E. Division Street
Telephone (503) 863-5201

EPA Interim Primary Drinking Water Standards

NAME GARD, Inc. Attn: Frank Budininkas DATE & TIME COLLECTED _____
ADDRESS 7449 N. Natchez Ave., Niles, Ill. 60648 DATE RECEIVED 10-30-78
WATER SOURCE Set #3 DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81030-1

TEST	TEST METHOD[1]	UNITS	LIMITS	TEST RESULTS	DATE OF ANALYSIS	ANALYST
ARSENIC	SM 404 C	MG/L	0.05	N.D.@ 0.01	11-1-78	MJS
BARIUM	SM 303 A	MG/L	1.	N.D.@ 0.1	11-2-78	MJS
CADMIUM	SM 305 A	MG/L	0.01	0.0014	11-7-78	DRG
CHROMIUM	SM 307 A	MG/L	0.05	N.D.@ 0.02	11-1-78	MJS
LEAD	SM 311 A	MG/L	0.05	0.019	11-7-78	DRG
MERCURY	SM 315 A	MG/L	0.002	0.079	11-9-78	DRG
NITRATE-NITROGEN	ASTM D992-71	MG/L	10.	0.9	11-1-78	MJS
SELENIUM	SM 318 C	MG/L	0.01	N.D.@ 0.002	11-1-78	MJS
SILVER	SM 319 A	MG/L	0.05	N.D.@ 0.01	11-1-78	MJS
FLUORIDE	SM 414A & C	MG/L	1.4 to 2.4	0.8	11-1-78	MJS
ENDRIN	SM 509 A	MG/L	0.0002	NOT TESTED		
LINDANE	SM 509 A	MG/L	0.004	" "		
METHOXYCHLOR	SM 509 A	MG/L	0.1	" "		
TOXAPHENE	SM 509 A	MG/L	0.005	" "		
2,4-D	SM 509 B	MG/L	0.1	" "		
2,4,5-TP SILVEX	SM 509 B	MG/L	0.01	" "		
pH	SM 424	pH Units		3.9	11-1-78	MJS
SPECIFIC CONDUCTANCE	SM 205	µMHO/CM		40	11-1-78	MJS

[1] EPA = Methods for the Chemical Analysis of Water & Wastes, 1974
SM = Standard Methods for the Examination of Water & Wastewater, 14th Edition
ASTM = ASTM Annual Standards, Part 31
N.D. = None Detectable

APPROVED BY: David F. Putnam

UMPQUA RESEARCH COMPANY

Water and Air Technology

P. O. Box 791 ◆ Telephone (503) 863-5201

626 N.E. Division Street Myrtle Creek, Oregon 97457

Gerald V. Colombo
David F. Putnam

TEST RESULTS

NAME GARD, Inc. ATTN Frank Budininkas DATE 10-30-78

ADDRESS 7449 N. Natchez Ave., Niles, Ill. 60648 DATE REPORTED 12-1-78

TEST	SOURCE	Set #3	ANALYSIS	ANALYST	
	DATE TESTED		DATE		
	SAMPLE # / UNITS	81030-1			
pH	pH Units	3.9	11-1-78	MJS	
SPECIFIC CONDUCTIVITY	μ mho/cm	40	11-1-78	MJS	
AMMONIA	mg/liter	0.13	11-20-78	DRG	
CYANIDE	mg/liter	T.D.S. 0.02	11-20-78	DRG	
G.C. SCAN	hydrocarbon	negative	12-1-78	GVC	
T.O.C.	mg/liter	0.9	11-27-78	DRG	

APPROVED BY David F. Putnam

Set #3

UMPQUA RESEARCH COMPANY

P. O. Box 791 ◆ 626 N.E. Division Street
Myrtle Creek, Oregon 97457 Telephone (503) 863-5201

PHYSICAL AND CHEMICAL TESTS REQUIRED BY OREGON STATE HEALTH DIVISION ADMINISTRATIVE RULES CHAPTER 333, MARCH 1976

NAME GARD, Inc. Attn: Frank Budininkas DATE & TIME COLLECTED _____
ADDRESS 7449 N. Natchez Ave., Niles, Ill. 60648 DATE RECEIVED 10-30-78
WATER SOURCE Set #3 DATE REPORTED 12-1-78
COLLECTED BY: _____ URC SAMPLE # 81030-1

TEST	TEST METHOD[1]	UNITS	OSHD LIMITS	TEST RESULTS	ANALYSIS DATE	ANALYST
ACIDITY	SM 403	MG/L	N.L.	8.4	11-14-78	DRG
CALCIUM	SM 306 A	MG/L	N.L.	0.92	11-2-78	MJS
CHLORIDES	SM 408 A	MG/L	250.	1.5	11-10-78	DRG
COLOR (APPARENT)	SM 204 A	COLOR	15.	5	11-1-78	RD
COPPER	SM 308 A	MG/L	1.0	N.D.@ 0.01	11-2-78	MJS
FLUORIDE	SM 414 C	MG/L	2.0	0.8	11-1-78	MJS
HARDNESS ($CaCO_3$)	SM 309 B	MG/L	N.L.	2	11-10-78	DRG
IRON	SM 310 B	MG/L	0.3	0.09	11-1-78	MJS
MAGNESIUM	SM 313 B	MG/L	N.L.	0.04	11-2-78	MJS
MANGANESE	SM 314 A	MG/L	0.05	N.D.@ 0.01	11-2-78	MJS
NITROGEN, NITRATE	ASTM D992-71	MG/L	10.	0.9	11-1-78	MJS
NITROGEN, NITRITE	EPA p.215	MG/L	N.L.	0.13	11-1-78	MJS
ODOR	SM 206	T.O.N.	3.	N.D.@ 1	11-2-78	DRG
pH	SM 424	pH	N.L.	3.9	11-1-78	MJS
*POTASSIUM	SM 317 A	MG/L	N.L.	0.13	11-2-78	MJS
SAND	SM 208 D,E	MG/L	2.	N.D.@ 0.1	11-15-78	DRG
SILICA	SM 426 B	MG/L	N.L.	0.21	11-3-78	DRG
SODIUM	SM 320 A	MG/L	N.L.	0.27	11-2-78	MJS
SOLIDS, TOTAL	SM 208 C	MG/L	1000.	3.0	11-15-78	DRG
SOLIDS, VOLATILE	SM 208 E	MG/L	N.L.	N.D.@ 0.1	11-16-78	DRG
*SPECIFIC CONDUCTANCE	SM 205	µMHO/CM	N.L.	40	11-1-78	MJS
SULFATES	SM 427 B	MG/L	250.	N.D.@ 0.5	11-15-78	DRG
TURBIDITY	SM 214 A	F	Filtered 1.0 Unfiltered 5.0	N.D.@ 0.1	11-1-78	RD
ZINC	SM 323 A	MG/L	5.0	0.18	11-1-78	MJS

*Required by Laboratory for completion of Ion Balance and Quality Control of the Results.
"N.L." means No Limit
N.D. means None Detectable

APPROVED BY: David F. Putnam

UMPQUA RESEARCH COMPANY

P. O. Box 791 ◆ 626 N.E. Division Street
Myrtle Creek, Oregon 97457 Telephone (503) 863-5732

GARD, Inc.
Niles, Ill.

ION BALANCE

Set #3.

Sample No.	81030-1			
CATIONS, meq/l:				
Ca^{++}	0.046			
Mg^{++}	0.003			
K^{+}	0.003			
Na^{+}	0.012			
H^{+}	0.126			
ΣCATIONS	0.190			
ANIONS, meq/l:				
HCO_3^{-}	0			
$CO_3^{=}$	0			
Cl^{-}	0.042			
NO_3^{-}	0.064			
$SO_4^{=}$	0			
Fl^{-}	0.105			
ΣANIONS	0.211			
|ΣANIONS - ΣCATIONS|	0.021			
0.1065 + 0.0155ΣANIONS	0.113			
Acceptable* Ion Balance	YES			

Remarks:

*For acceptable comparability, $|\Sigma\text{ANIONS} - \Sigma\text{CATIONS}| \leq 0.1065 + 0.0155\Sigma\text{ANIONS}$

Set #1

UMPQUA RESEARCH COMPANY

Ion Balance and Data Check Sheet

Sample # 71020-1 Site Niles, CA

Client CARD, Inc Source NACA - Water Survey Calc by BPP

CATIONS	mg/l		me/l		μmho-cm^{-1} @ 25°C
Ca^{++} =	0.73	÷ 20.04 =	0.036	x 52.0 =	1.9
Mg^{++} =	0.09	÷ 12.16 =	0.007	x 46.6 =	.3
K^{+} =	0.05	÷ 39.10 =	0.001	x 72.0 =	
Na^{+} =	0.23	÷ 22.99 =	0.010	x 48.9 =	
H^{+} =		÷ =	0.154	=	
Σ CATIONS=		Σ CATIONS=	0.212	Σ CATIONS=	
ANIONS					
HCO_3^{-}=	----	÷ 61.02 =		x 43.6 =	
$CO_3^{=}$=	----	÷ 30.01 =		x 84.6 =	
Cl^{-} =	2.6	÷ 35.45 =	0.073	x 75.9 =	
NO_3^{-} =	4.13	÷ 62.01 =	0.071	x 71.0 =	
$SO_4^{=}$ =	N.T.	÷ 48.03 =		x 73.9 =	
F^{-} =	1.0	÷ 19 =	0.053	x =	
Σ ANIONS=		Σ ANIONS =	0.197	Σ ANIONS =	
Σ IONS=		Δ IONS =	0.015	Σ IONS =	
TDS=		Δ MAX =	±0.113	K_∞ =	
		TDS / K Normal =		K =	59
SiO_2=2.14 Si=		Range =	0.55 to 0.7	pH =	3.2
TSS=					
TS=					

1.0 = NO_3 - N
4.43
NO_3

NOTES

1. HCO_3^{-} = Alkalinity as $CaCO_3$ _____ x 1.22 = _____
2. $CO_3^{=}$ = Present only if pH > 8.3
3. Δ IONS = Σ ANIONS - Σ CATIONS
4. Δ MAX = ± (0.1065 + 0.0155 Σ ANIONS)
5. $K_\infty = DK_d - (D - 1)K_w$

   Where: D = Dilution required to make $90 \leq K \leq 120$ μmho-cm^{-1}

   $= \frac{Vs + Vw}{Vs}$

   Vs = Volume of Sample
   Vw = Volume of Distilled Water
   Kd = K of Diluted Sample
   Kw = K of Distilled Water (< 2 μmho-cm^{-1})

HARDNESS AS $CaCO_3$

Ca x 2.497 =	
Mg x 4.116 =	
Sr x 1.142 =	
Fe x 1.792 =	
Al x 5.564 =	
Zn x 1.531 =	
Mn x 1.822 =	
TOTAL =	
EDTA =	0.7

Lot 2.

UMPQUA RESEARCH COMPANY

Ion Balance and Data Check Sheet

81020-2

Sample # GAID, INC Site M.I.S. III

Client GAID, INC Source NASA. Water Supply Calc by DFP 11-21-78

CATIONS	mg/l		me/l		µmho-cm^{-1} @ 25°C
Ca^{++} =	0.69	÷ 20.04 =	0.034	x 52.0 =	1.8
Mg^{++} =	0.09	÷ 12.16 =	0.007	x 46.6 =	0.3
K^{+} =	0.07	÷ 39.10 =	0.002	x 72.0 =	0.1
Na^{+} =	0.24	÷ 22.99 =	0.010	x 48.9 =	0.5
H^{+} =		÷ =	0.251	=	≈ 90
Σ CATIONS=		Σ CATIONS=	0.304	Σ CATIONS=	
ANIONS					
HCO_3^{-} =	4.2	÷ 61.02 =	0.282	x 43.6 =	12.3
$CO_3^{=}$ =		÷ 30.01 =		x 84.6 =	
Cl^{-} =	5.57	÷ 35.45 =	0.157	x 75.9 =	12.0
1.43 x .7 NO_3^{-} =	3.10	÷ 62.01 =	0.050	x 71.0 =	3.6
$SO_4^{=}$ =	0.29	÷ 48.03 =	0.006	x 73.9 =	0.4
Fl^{-} =	1.9	÷ [illegible] =	0.100	x =	
Σ ANIONS=		Σ ANIONS =	0.314	Σ ANIONS =	
Σ IONS=		Δ IONS =	0.010	Σ IONS =	
TDS=		Δ MAX =	± 0.116	K_∞ =	
		TDS / K Normal Range =	0.55 to 0.7	K =	92
SiO_2=2.14 Si=				pH =	3.6
TSS=					
TS=	1.8				

NOTES

1. HCO_3^{-} = Alkalinity as $CaCO_3$ 14.1 x 1.22 = 17.2
2. $CO_3^{=}$ = Present only if pH > 8.3
3. Δ IONS = Σ ANIONS - Σ CATIONS
4. Δ MAX = ± (0.1065 + 0.0155 Σ ANIONS)
5. $K_\infty = DK_d - (D - 1)K_w$

   Where: D = Dilution required to make $90 \leq K \leq 120$ µmho-cm^{-1}

   $= \frac{Vs + Vw}{Vs}$

   Vs = Volume of Sample
   Vw = Volume of Distilled Water
   Kd = K of Diluted Sample
   Kw = K of Distilled Water (< 2 µmho-cm^{-1})

HARDNESS AS $CaCO_3$

0.69 Ca x 2.497 =	1.72
0.09 Mg x 4.116 =	.37
Sr x 1.142 =	
0.29 Fe x 1.792 =	.52
Al x 5.564 =	
Zn x 1.531 =	
Mn x 1.822 =	
TOTAL =	
EDTA =	2.0

UMPQUA RESEARCH COMPANY

Ion Balance and Data Check Sheet

Sample # [illegible] Site [illegible]

Client [illegible] Source [illegible] Calc by [illegible]

CATIONS	mg/l		me/l		µmho-cm^{-1} @ 25°C
Ca^{++} =	0.92	÷ 20.04 =	0.046	x 52.0 =	[illegible]
Mg^{++} =	[illegible]	÷ 12.16 =	0.003	x 46.6 =	
K^{+} =	[illegible]	÷ 39.10 =	[illegible]	x 72.0 =	
Na^{+} =	0.27	÷ 22.99 =	0.012	x 48.9 =	
I⁻ =		÷ =	0.121	=	
Σ CATIONS=		Σ CATIONS=	0.182	Σ CATIONS=	
ANIONS					
$HCO_3^{=}$ =		÷ 61.02 =		x 43.6 =	
$CO_3^{=}$ =		÷ 30.01 =		x 84.6 =	
Cl^{-} =	1.5	÷ 35.45 =	0.042	x 75.9 =	
NO_3^{-} =	[illegible]	÷ 62.01 =	[illegible]	x 71.0 =	
$SO_4^{=}$ =		÷ 48.03 =		x 73.9 =	
Fi =	2.0	÷ 190 =	0.105	x =	
Σ ANIONS=		Σ ANIONS =	0.221	Σ ANIONS =	
Σ IONS=		Δ IONS =	[illegible]	Σ IONS =	
TDS=	[illegible]	Δ MAX =	± 0.13	K_∞ =	
SiO_2=2.14 Si=		TDS / K Normal =		K =	40
TSS=		Range =	0.55 to 0.7	pH =	[illegible]
TS=					

NOTES

1. $HCO_3^{=}$ = Alkalinity as $CaCO_3$ [illegible] x 1.22 = [illegible]
2. $CO_3^{=}$ = Present only if pH > 8.3
3. Δ IONS = Σ ANIONS - Σ CATIONS
4. Δ MAX = ± (0.1065 + 0.0155 Σ ANIONS)
5. $K_\infty = DK_d - (D - 1)K_W$

   Where: D = Dilution required to make $90 \leq K \leq 120$ µmho-cm^{-1}

   $= \frac{Vs + Vw}{Vs}$

   Vs = Volume of Sample

   Vw = Volume of Distilled Water

   Kd = K of Diluted Sample

   Kw = K of Distilled Water (< 2 µmho-cm^{-1})

HARDNESS AS $CaCO_3$

Ca x 2.497 =	[illegible]	
Mg x 4.116 =	0.2	
Sr x 1.142 =	[illegible]	
Fe x 1.792 =	0.2	
Al x 5.564 =		
Zn x 1.531 =	[illegible]	
Mn x 1.822 =		
TOTAL =	[illegible]	
EDTA =	[illegible]	

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